Practical Application of Industrial Exhaust Ventilation for the Control of Occupational Exposures*

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THE development of any type of engineering control for the protection of industrial health must be based on: (1) A specific job analysis of the operation or operations performed; (2) A study of operator technic; (3) Engineering and scientific data for developing control of the hazard involved.

To the layman there is no glamour to a drawing or an exhaust system, but to control engineers who, with the physician and chemist, form a tripod of attack for the protection of industrial health in the plants of this country, a properly designed and satisfactorily functioning exhaust system signifies something that is alive for it represents positive protection for the health of industrial workers.

FUMES AND ODORS

Certain industrial operations are productive of annoying and irritating fumes and odors. Among these may be mentioned acrolein which results from the decomposition of oil or materials containing oils or fats.

In the manufacture of strip copper, the billet, having been previously brought to proper rolling temperature in a preheating furnace, is carried to the roll table in front of the reducing rolls by means of an electric hoist suspended from an overhead monorail. It is then passed back and forth through the rolls to be reduced to the required gauge. The insides of the rolls are water-cooled. The surface of the rolls is swabbed with a special grease mixture to prevent the formation of scale or oxidation of the surface of the copper slab. In view of the fact that two operators are located directly in front of the roll table on the entering side or front of the rolls, one operator being located on the rear or leaving side, while a gauge operator on the side of the rolls regulates the roll displacement as the slab passes back and forth through the rolls, it was thought that the control of the dissemination of steam, flame, and large volumes of acrolein vapors could not be satisfactorily accomplished. This operation has been performed for many years without any control. As a result, the interior of the building structure directly above the rolls is covered with a hard deposit of carbonaceous material, which, aside

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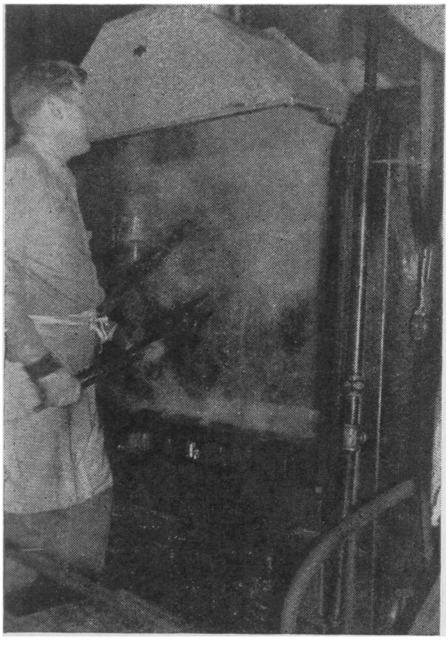
from being unsightly, also presented a fire hazard. On days when the humidity was high or when doors and windows were closed during the winter, the heavy vapors dispersed throughout the entire shop area to the discomfort of all workers.

About a year ago an attempt was made to catch and exhaust these vapors. A sheet metal hood 7′ x 7′ was located directly over the rolls and about 12′ above the floor line, so as to clear all of the monorail structure. A 12″ dia. exhaust duct was connected to this hood and approximately 3,000–3,500 c.f.m. were exhausted. The original motor on the job was 7½ H.P. As soon as the system was operated it was found to be inadequate. The motor was changed to a 10 H.P. and then to a 20 H.P. with the hope that more air would be exhausted. Not realizing the relationship between fan performance and system characteristic, a point was soon reached where excess power was consumed without any additional effective control at the rolls.

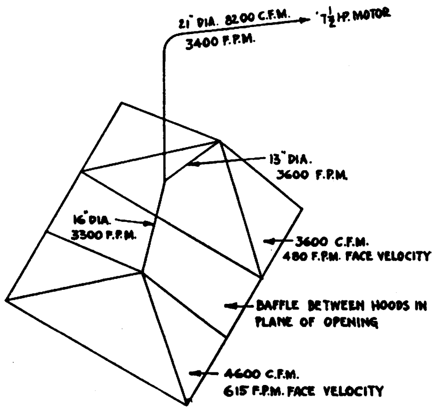
The present installation is the result of a proper analysis of the various factors involved. The location of the preheating furnace relative to the rolls precluded any different method of billet handlings than that which is at present being used, i.e., the overhead monorail and chain-hoist is one controlling factor in the location of any exhaust hoods or ducts. To catch the steam, flame, and acrolein vapors effectively, any hoods must, of necessity, be close to the rolls. They could not extend very far forward or to the rear of the rolls due to the presence of the three operators. The front hood location was practically set as it could not come forward of the point where the hoist-chain was located when the billet was lowered to the roll slab. Again, hoods could not be dropped below the

FIGURE 1

Hot billet being sent through the roll—no vapor or steam in front of the hood



Arrangement schematically presented



heads of the operators in front or rear of the rolls nor could panels be dropped on the sides of the hoods, for they would interfere with the vision of the gauge operator. Since most of the irritating acrolein vapors from the rolls were generated in front as soon as the hot billet came in contact with the greased cool roll, more air was exhausted from the front hood. The arrangement is schematically presented in Figure 1 together with all of the air engineering data for the entire system. The result of the installation is shown in the picture taken just when a hot billet was being sent through the rolls. Not a whisp of vapor or steam rolls past the front edge of the hood.

The elimination of this exposure is based entirely on engineering control. The system calls for large air volumes and high face velocities at the lower face of the exhaust hoods, 615 f.p.m. and 450 f.p.m., respectively.

LEAD

An unusual lead exposure presented itself in the manufacture of an electrical specialty.

A call was received from the plant owner that some of his female employees were becoming ill. One of the girls had complained of severe abdominal pains.

The section of the plant where the trouble developed was a partitioned portion 26′ long x 13′ wide and 11′ high. One long and one short side contained movable steel sash. Three female and two male operators performed certain operations incident to the manufacture of these specialties. A survey of the work area and a cursory examination of the operators indicated a possible lead exposure, though the owner stated that as far as he knew, no lead of any kind was present in any of the materials used in the manufacture of his products. Samples of all the materials used in the process were obtained and analyzed by our chemists. One of the materials contained between 50 and 60 per cent lead, presumably as a borosilicate. The owner communicated with the manufacturer of this material and was informed that "it did contain a considerable amount of lead."

As a result of the first lead study which showed lead concentrations ranging from 7 to 15 mg./10 M^3 (7–15 mg. per 10 cu.m. of air), the following recommendations were transmitted with the report and thoroughly discussed with the management.

1. Bottles of drinking water and milk should be removed from the work area. When workers require water they should be supplied with paper cups or a bubbler fountain should be provided and located outside the work area.
2. Candy, chewing-gum, or food of any kind should not be eaten in the work area.
3. An inclined tumbling barrel wherein the ingredients were mixed should be removed from the work area and placed in an isolated enclosure, said enclosure to be provided with a propeller fan for general ventilation.
4. The operator working in the area wherein the tumbling barrel is located, should be provided with and use a respirator approved for protection against the inhalation of lead dust.
5. Specific recommendations were outlined covering changed technic in the mixing, dumping, and storage of the mixed materials.
6. Female operator technic of flipping flannel cloths against legs of the supporting table to remove excess material dropped from the specialties during their progress in the work area should be immediately stopped. This operation alone was found to contribute considerable dust and lead to the general work area. These cloths were found necessary to protect the chrome-plated surface of the specialties from becoming scratched.
7. No cleaning of any kind should be performed during working hours—especially dry brushing of the work tables—but preferably after working hours and by an operator protected with an approved lead dust respirator. A small portable vacuum cleaner would be a desirable piece of equipment for this purpose.
8. The solid metal top of the 14′ long x 18″ wide work table should be provided with screen or grille sections at the operator stations, each grille section to be located over a hopper and each hopper to be connected to a main exhaust system to discharge outdoors to a dust collector.
9. Previous to any ventilation installation, and after the tumbling barrel has been removed, ceiling, walls, floor, windows, and

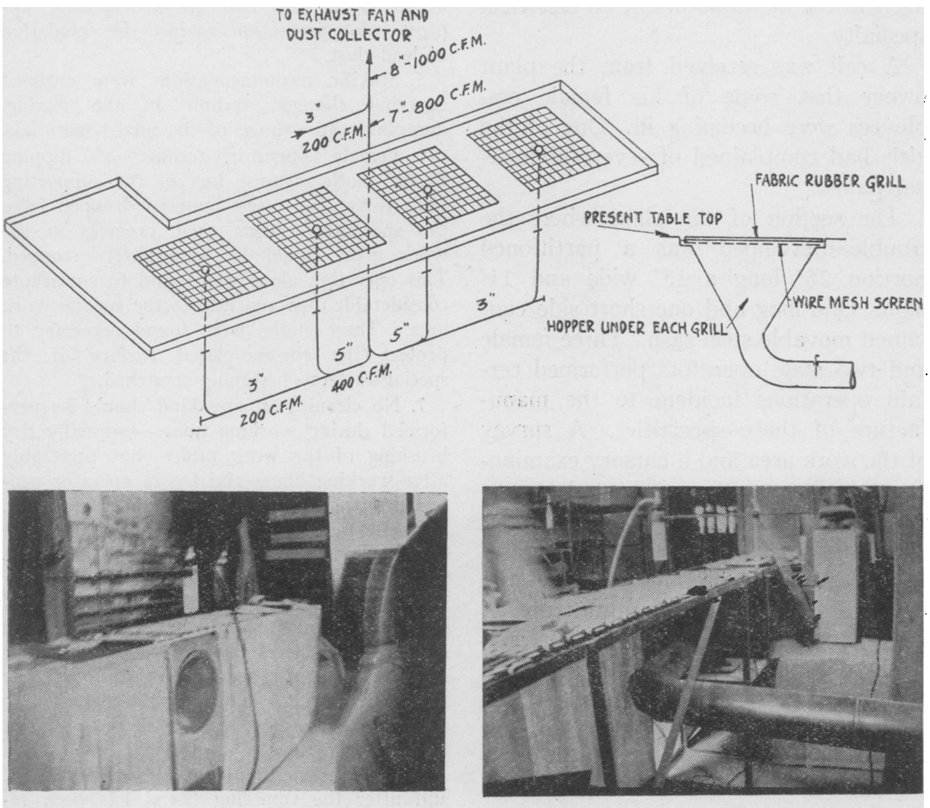
work tables should be thoroughly flushed with water to remove all present dust deposits.

Recommendations 1, 2, 3, 4, 5, 7, and 9 were immediately complied with. Suggestion 8 is schematically illustrated in the upper portion of Figure 2. At each working position a rubber covered grille about 18″ x 10″ is set into depressions in the working face of the table as shown in the upper right-hand section of the sketch. Each grille is to handle about 200 c.f.m. at a net face velocity through the openings of 100 f.p.m., and a fan unit is to provide 800–1,000 c.f.m. exhaust capacity. Duct velocities averaged about 3,000 f.p.m.

The first attempt by the management is shown at " A " and " B." The solid top of the table was replaced by a heavy wire mesh set between the angle iron edges of the table. On top of this mesh were placed small fabric-rubber mats. Canvas curtains were placed along the front of the table down to the floor. At each work station, though not shown in either of these illustrations, inclined solid metal trays extended from the under side of the mesh grille to tote-boxes on the floor. These were to catch any material dropped through the grille top from the specialties as they progressed from operation to operation along the top of the table. About half way along the length of the table a

FIGURE 2

Schematic arrangement for down draft ventilated table—" A " and " B," front and rear views of attempted control



" A " " B "

metal panel was located, containing a 12″ dia. copper reflector, salvaged from a reflector-type bathroom heater. The inside of the reflector was connected to a 6″ dia. inlet of a small direct-connected fan unit operated by a 1/8 H.P., 1,740 r.p.m. motor. The 3″ dia. outlet of the fan was located inside a 6″ dia. stove-pipe, shown at "B." This pipe extended through a hole in the building wall to the outside. Neither trap nor collector was connected to the end of this pipe. The idea of the reflector and fan installation was for the operators to flip their flannel cloths against the grille in front of the reflector so that all the dust would be immediately exhausted outdoors. When not so used, the fan was supposed to aid materially in purging the general work area of lead dust.

From an engineering standpoint, the installation was entirely psychological and typical of many industrial exhaust installations operating today.

After these changes, a second dust study was made, sampling points being the same as in the first study. Atmospheric lead concentrations ranged from 4 to 5.5 mg./10 M^3. This was a considerable reduction from the 7 to 15 mg. range of the first study. The reduction in concentration is to be attributed to the removal of the inclined tumbling barrel from the work area, some improved operator technic, and especially the purchase of a portable vacuum cleaner, the effective results of which were immediately manifested by the improved housekeeping and reduction of deposited dust throughout the work area.

Some time after the second study was completed, arrangements were made with the private physician employed by the plant to obtain blood smears of all operators with a view of making basophilic aggregation tests to determine the extent of lead absorption. Due to press of our own laboratory work it is indeed unfortunate that the lead smears were not obtained when the trouble started a few months previously. Again, smears were not obtained at regular intervals so that curves cannot be plotted to show the reduction of the basophilic from time to time. Original samples ranged from 1 to 2.5 per cent and then dropped to 1 per cent and 0.5 per cent. McCord and his associates state:

> In the adult healthy human, the percentage of basophilic aggregations is usually below 1.0 per cent, frequently as high as 1.5 per cent but rarely as high as 2.0 per cent. In the use of this testing procedure in connection with the diagnosis of lead poisoning or lead absorption, no consideration is usually attached to findings until the number of basophilic aggregations rises above 1.5 per cent or 2.0 per cent.

The results of the second study were transmitted to the management and interpreted to the extent that a serious lead hazard still existed in this work area. The down-draft ventilated grilled-top hoppers were then installed. Slide type blast gates were installed at each hopper to regulate the air-flow. A cyclone dust arrestor was also located outside the building wall between two wings of the plant buildings. The only criticism that the management had of the ventilated hoppers was that they were trapping and exhausting to the dust arrestor about 16 per cent of the material daily prepared to be used in the electrical specialties. This seemed too great a loss, so modifications to the system were immediately made. Dust traps were made for the bottom of each hopper. These traps, 11″ dia. x 19″ high, caught practically all of the heavy material while only the fine dust, not necessary for the specialties, was exhausted to the arrestor outdoors.

No further sickness or complaints of any kind have been received by the management from the workers in this section since the new ventilation system has been in operation. Up to date, bureau activities have prevented a final check study but this will be made in the near future.

The elimination of this exposure is based on chemical and engineering control. Closer medical control through early and continued basophilic aggregation tests would have been of material aid in the solution of this serious exposure.

SILICA

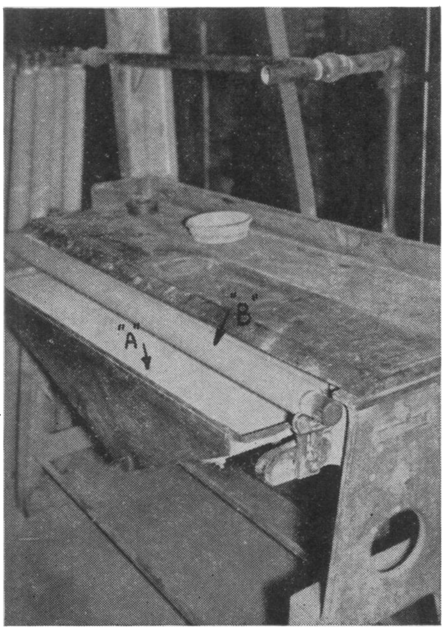
As a result of a general survey of an industry in the state, there was uncovered a very serious silica exposure, one which has been prevalent in the industry for the past 25 years.

In the manufacture of tubing, many of the sizes are produced from solid billets by means of extrusion machines. Some sizes, depending on wall thickness, require that short sections of the tube be cast and then extruded to finished dimensions. To cast these tubes, a sand core is required, and it is during one of the operations in the series pertaining to the core preparation that the silica exposure is serious.

Various grades of beach and building sand are intimately mixed in a standard foundry Simpson mixer until a "mud" of proper consistency has been developed.

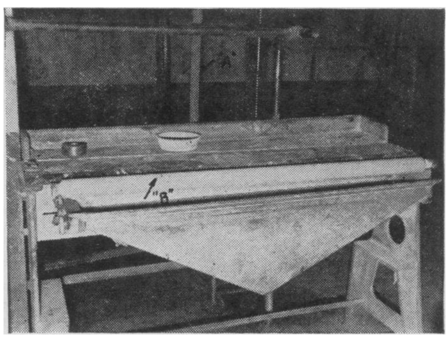
A hollow, perforated, steel core mandrel is next covered with asbestos paper. This is done on a bench containing two sets of small rolls for supporting the ends of the mandrel. Depending on the particular diameter core desired, an adjustable steel knife edge is set at the proper distance from the center of the steel mandrel. Pails of the prepared "mud" are dumped on the table in back of the mandrel. Some plants use

FIGURE 3



Three-quarter side view showing screen top of hopper "A" and sand ridge "B"

Hand sanding operation to remove ridge and to bring cores to proper diameter



Front view of hopper arrangement for core sanding operation for removal of ridge "B"—flexible exhaust tube "A" connecting to rear of hopper a regulated electric drive, others use a hand-operated crank to turn the steel mandrel while a second operator keeps feeding the " mud " onto the revolving mandrel by hand. In time, the proper thickness of the first rough coat has been applied. These cores are then placed on end in steam coil dryers and kept there for 24 hours at a pre-determined temperature. Many cores require a double layer of " mud " to build it up to the proper diameter, while others just require the first application. In either event, the hand sanding operation produces excessive concentrations of silica dust with resulting exposure to all of the operators concerned. As may be seen in Figure 3, a longitudinal ridge is left on the core face. This ridge cannot be smoothed off while the " mud " is moist. The usual procedure is to stand the dried core on end, use sandpaper, a leather glove or a piece of fine mesh screen and rub off the ridge. This ridge must be removed from either the first or second layer of " mud " or it produces a ridge inside the tube when it is cast.

A chemical analysis of settled dust from one plant, taken from the top of an oven 7′ 0″ above the floor showed 35 per cent free silica, while a sample of dust from the floor where the core sanding operators were stationed showed 58 per cent free silica. At another plant settled dust over an oven door carrier showed 42 per cent free silica while a sample of dust from the floor and from a bench adjacent to the core sanding operator showed 71 per cent free silica.

Concentrations of dust to which core sanding operators were exposed in the first plant showed a value of 125 M.p. per cu. ft. of air while in the second plant a count of 265 M.p. per cu. ft. of air was obtained.

The nature of the exposure and the dust concentrations involved precluded any arguments as to the necessity or desirability for immediate and effective control. The basis of the control was already present in every one of the plants involved, namely the core benches themselves.

Sketches were prepared right on the job during the period when the engineering survey was being made. A screen-top hopper was suggested under the cores to be sanded. One company had an old, unused industrial vacuum cleaner, so they connected it to a 1½″ dia. stub at the rear of the hopper. The sanding operation, instead of being performed in an up-and-down manner, and quite vigorously, is now performed with the core and mandrel in a horizontal position on the core lathe while the operator slowly passes his glove or sandpaper or mesh screen over the ridge and then the body of the core, if found necessary to bring the ends to the proper diameter. Maximum concentrations resulting from this latter technic are about 1 M.p. per cu. ft. of air. Housekeeping was so improved that the management of one plant is equipping similar operations in five of its plants with exhaust, though fans are to be used for suction instead of a vacuum cleaner.

Air determinations over the unit connected to the industrial vacuum cleaner were made with the heated thermometer anemometer. Readings were taken on the longitudinal center line of the 9″ wide screen top of the hood. Both thermometers were held about 1″ apart and about 2½″ above the screen top. Four volts were used in taking the readings. Results indicated a face velocity of approximately 68 f.p.m., quite low for normal industrial practice. The effectiveness of the screen top and the decided change in operator technic does not require any larger face velocity—gravity also helping to drop the fines to the hopper. For a fan installation at another plant, it was suggested that 375 c.f.m. be exhausted through the screen-top resulting in a face velocity of 104 f.p.m. A 5″ dia. exhaust connection is necessary resulting in a pipe velocity of 2,800 f.p.m. with this higher air volume. A twin hopper, each with a 3½″ dia. tap, connecting to a 5″ dia. exhaust is a more effective arrangement. The same air volume per bench is to be exhausted as for the single hopper.

One installation is complete and operating successfully with the industrial vacuum cleaner as the source of suction, another is in the process of installation, while a third plant, due to the use of a new extruding machine, has discontinued the manufacture of 90 per cent of the sand cores previously found necessary in the older method of casting tubes. The cores which are necessary to be made for the larger tubes are sanded with the mandrels on end due to the excessive weight of both steel mandrel and core, and the operators are supplied with and use approved type respirators for their protection against the inhalation of the high silica dust developed during the sanding operation requiring approximately one hour every day for its completion

The elimination of this exposure is based on chemical and engineering control.

BENZOL

Benzol, in spite of its toxicity, still maintains its position as the most valuable and effective industrial solvent.

Medical control, through the utilization of the urine sulphate test for the determination of benzol absorption previous to definite systemic poisoning, was the medium through which a serious benzol exposure was brought to light. Benzol has been used in various departments of one plant for a number of years. The use of the urine sulphate test for all of the operators involved throughout the plant soon demonstrated that though some of the percentages of inorganic to total sulphates were somewhat below what is considered normal, in the majority of cases they could be dismissed. When an analysis was made of the data pertaining to operators in the hand lacquer dipping division, certain pertinent facts were disclosed. Different types of lacquers, necessary for the varied work being processed, required varying amounts of benzol as a solvent. When the percentage of benzol reached certain proportions, and this only occurred in certain operating sections, thus localizing the problem, the urine sulphate test immediately demonstrated potential danger to the operators involved. The problem narrowed itself down to two operators who were most seriously exposed. Both of these men have been in this department for years without any apparent outward manifestation of physical disability. One is tall and heavy set while the other is short and slim. For a period of 3 months, operator "S," the heavy individual, seemed to be failing in health. During this period, 7 urine sulphate tests were made, and 2 of the early samples showed a 34 per cent ratio—definitely in the danger zone. The smaller of the two operators, to be designated as operator "P" showed normal ratios during this same period. A reason for this is to be advanced later in this discussion. Operator "S" was then transferred from the benzol exposure to other work in the department. During this period, 6 urine sulphate tests were made and they appeared quite normal. In the meantime, the ratios of operator "P" were swinging up and down, though no alarm was felt for him because he did not become ill.

It was during the transfer period of operator "S" that the bureau was called upon for help. A complete engineering survey was made of four hand lacquer dipping stations. Coincident with this survey atmospheric determinations were made to ascertain the exposure of the operators to benzol during cycles of their operations. This was obtained by the use of nitrating tubes containing concentrated sulphuric and fuming nitric acids—the results being determined colorimetrically. The values obtained ranged from 22 to 63 p.p.m. Our bureau regulations require that benzol should not be present in concentrations over 100 p.p.m. This is based on pathological data and experience, and in the majority of instances may be entirely justified. However, this one plant experience of illness and concentrations below 100 p.p.m. seems to add to the picture of experience recently presented by Dr. Elkins, of Massachusetts. It is not intended, at a gathering such as this, to argue one way or another about a problem of such importance. This we will graciously leave to the chemists and pathologists. Since effective control must always be predicated on the work of these two groups, this control must of necessity be flexible so as to be varied as knowledge concerning the pathological effects of low concentrations of toxic materials over prolonged periods of exposure, is evaluated.

In spite of the low benzol concentrations found, and aside from the state regulation in the official report presented to the executives of the organization, it was suggested that ventilation be installed, as a matter of good industrial practice. It was also suggested that the urine sulphate tests be continued until after all control measures had been installed and for some time afterwards. Atmospheric determinations would then be made to determine the effectiveness of the control measures suggested and installed.

One of the four lacquer dipping sections may be designated as the east unit, while the other three, where operators " S " and " P " are located may be designated as the west unit. The east unit will first be discussed.

No control of any kind was provided over the dip crocks. The steam heated drying oven was provided with a 13″ wide hood extending over the entire 6′ 0″ width of the oven and located above the doors. A 7″ dia. exhaust duct was connected to the center of this hood. Eight 2½″ dial holes had been cut in the two front doors of the oven presumably for venting purposes.

Based on the engineering recommendations contained in the report of the study, and in consultation with our bureau, engineering data were developed and drawings made for changes in this east unit. The lacquer was contained in crocks. These crocks were set in metal containers to catch any drippings and this latter container was set in a ventilated metal shell. This ventilated shell is set 3″ above the inner metal container so that any heavy vapors dropping from the racked work as it is withdrawn from the crock will not spill over to the work area. Each ventilated shell is connected to a 5″ dia. duct, exhausting 300 c.f.m. at 2,200 f.p.m. in this connection. The air velocity between the metal shells is 170 f.p.m.

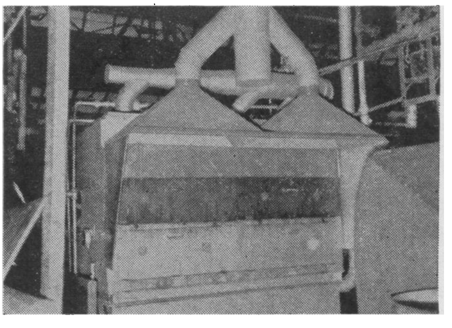
All crocks are supplied with hinged metal covers and are kept in place except when the specific crock is being used. If only one lacquer crock is being used, there being two lacquer crocks, one drain crock and one special wash crock, the ventilation is continuously operating, the covers on the unused crocks are kept closed and air is exhausted from between the shells of all four crocks. To prevent air currents from overhead monitors or drafts from adjacent openings in the partition walls affecting the exhaust system, a hinged top enclosure was installed over all of the crocks. The location of the forward edge of the hinged top was determined by studying and correcting operator technic, when the racked work was being withdrawn from the dipping operations. The control about these crocks has completely eliminated any odor of benzol in this work area and has definitely prevented the dispersion of any benzol vapors to adjacent operators.

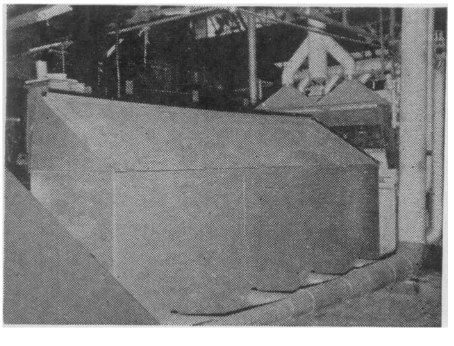
Three modifications at the oven finally cleared the work area of all benzol odors. The eight holes in the oven doors were sealed with metal discs. A 4" dia. exhaust tap was connected from the bottom of the oven to the main exhaust line and supplied with a slide type blast gate. This 4" duct is used for purging the oven of the heated benzol vapors and lacquer odors. This blast gate is only slightly "cracked open" and the exhaust is so nicely balanced that the oven temperature necessary for proper drying has been maintained. When the oven doors are open for removal of the racked material, no odors or vapors are discharged to the operator's breathing zone and then dispersed to the general work area, due to the oven being under a slight suction.

The original 13" wide, single hood over the front of the oven was removed and a double 20" wide hood substituted. A 6" dia. connection to the top of each hood section exhausts 500 c.f.m. at 2,550 f.p.m. velocity in each connection. This 1,000 c.f.m. exhaust provides 100 f.p.m. velocity on the under side of the hood, too low for normal hood exhaust. In view of the expected and resulting excellent purging of the oven, this low face velocity was found to be sufficient. Draft guards, one on each outer side of the hoods, 28" long and tapered from 20" to 10" prevent side air drafts from whipping any

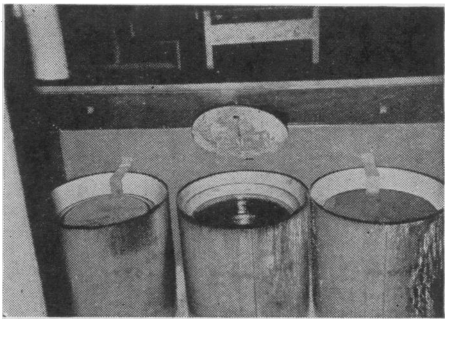
FIGURE 4

Close-up of double hood arrangement with draft guards in place





Rear of enclosure over crocks showing exhaust piping arrangement from shells



Crocks set in ventilated shells inside of enclosure—center lacquer crock being used benzol vapors or lacquer odors out of the oven when the doors are opened.

The installations just described for the east unit are shown in Figure 4. Crocks, inner and outer shells, hinged covers, enclosure over the shells and crocks, exhaust system from ventiltaed shells, oven hoods and exhaust connections and draft guards are clearly shown. The ventilation about the crocks and the purging of the oven were the main control items in the east unit.

The west unit presented exhaust problems not present in the east unit just described. There are three operating stations, though the two outer units are normally used. Each unit consists of three lacquer crocks, two sets of mechanisms for rotating the mesh baskets, containing dipped work, to remove excess lacquer and two steam heated drying ovens. Benzol is disseminated from dipping, rotating, and drying operations—the worst dissemination point being the ovens.

The three units are set in line, operator " P " being located at the farther unit near a large opening in the partition wall, while operator " S " is located at the third unit in the line. There was no control of any kind originally provided for any of these units. The only air movement provided was by the fans in the oven set-up which recirculated the benzol-laden air through heater and work.

The prolific source of dispersion was from the leaky ovens. Sheet metal screws and cement were freely used and all open joints and loose sheet metal parts were made absolutely tight. The focal point of attack for control was at the rear unit where operator "S " is located. The discharge from the circulating fan, set on the floor, is to a baffled opening in a heater casing set over the fan. The fan connection was not tight, so that a major portion of the benzol laden air being drawn from the bottom of the dryer housing was discharged against the baffle and was then deflected to the floor. The velocity of discharge and the fact that these vapors were hot aided in their dissemination to the breathing zone of the operator and then to the general work area of the department. The large opening in the partition wall near where operator " P " is located caused an appreciable draft from operator " P " to operator " S " with the result that the odors of benzol and lacquer were decidedly annoying and irritating at the latter work station—this in spite of the fact that approximately the same benzol concentrations were found at each work station, namely 63 p.p.m. The absence of odors eliminated operator " P " from consideration for the time being, and his potentially dangerous condition was only demonstrated when the bureau plotted the results of the urine sulphate tests. This will be discussed later.

A sheet metal casing was dropped from the bottom of the heater casing to the floor, entirely enclosing the cast iron fan casing. A 4″ dia. exhaust duct, provided with a slide type blast gate, similar to that installed for the oven at the east unit, was connected from the oven to an exhaust line. The sealing of all open joints in this oven, together with its proper venting and baffling of the lower section of the heater casing about the fan immediately produced a remarkable change in the working area. This was decidedly noticeable as operator " S " worked between two ovens, as did operator " P " but the former was also in the zone of the draft from operator " P " carrying benzol vapors from the farther operating station.

Since the work to be hand-lacquered was contained in heavy mesh baskets and not racked as at the east unit, a large shallow enclosure, almost like a spray paint hood was developed. The weight of the basket and its material necessitated a 1¼″ dia. pipe rail support for the operator so that he could grasp this support when he lifted the basket from the dip crocks. These crocks are supplied with annular ventilated shells similar to that at the east unit. It is contemplated that the height of the hood will be reduced so that the operator's head will not be in the hood above the crocks when dipping is being performed. The weight of the basket and work may preclude this.

Up to the present time, effective control has been provided only for operator "S." Due to the results from this one work station, an engineering layout was prepared and approved by the management for all three operating sections of the west unit. Location of dipping crocks, rotating mechanisms and ovens have been rearranged to facilitate easier handling of the work and to aid in the ventilation of these dispersion points. Work is at present being done in connection with this major operating change.

The new layout includes a ventilated enclosure for the rotating mechanisms while the basket and work are rotated to remove excess lacquer, and an exhaust tap is to be provided for the drip container under each mechanism to remove any possible benzol vapor collecting in these containers.

Brass wheels in the fans and completely grounded systems were recommended for all of the systems involved.

Some significant points relative to the plot of the urine sulphate ratios may be mentioned:

1. To date, 35 samples of each operator have been plotted.
2. The sample taken on March 23 of operator "S" a short time after his return to the benzol exposure, and apparently after his system was cleared of benzol, showed a ratio of 31 per cent—the lowest it had ever dropped to.
3. The gyrations of the ratios of operator "P" may be explained by the fact that when the center of the three dipping units is in operation, for some unknown reason the area between this unit and operator "P" is heavy with benzol and lacquer odors, this in spite of the draft from operator "P" toward the center unit. Personal susceptibility may also be an important factor here. This may possibly be eliminated because the ratio of 59 per cent on August 10 resulted from the operation of the center unit, which also accounts for the jumps in February and March. The center unit is used periodically and only on special work.

This benzol exposure has been discussed at great length, first due to the toxicity of the material and second due to the possible change of our knowledge of the effects of continued low concentrations over long operating periods. If the data of Dr. Elkins or Dr. Hunter are to be viewed in their proper light, trouble is to be expected from further exposing operators "S" and "P" to this toxic solvent.

The careful development of proper and adequate engineering controls for the protection of industrial health against occupational exposures means that each problem encountered requires a "tailor-made" analysis. This factor should never be lost sight of because in the final analysis a life may depend on the effectiveness of the control utilized.

DISCUSSION

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THIS paper outlines four specific ventilation problems and describes the solution of each. We are not inclined to disagree with any of the statements in the paper, and take the opportunity to direct attention to several outstanding items.

In each instance the ventilating equip-